APPENDIX F: ReMAP Task Force Meeting with the International Partners

Representatives from NASA, CSA, ESA, and NASDA met with members of the ReMAP Task Force IP Subcommittee on April 19, 2001 to develop an understanding of International Partner (IP) priorities. The objectives of the meeting were to help determine capabilities NASA does and does not have in its priority areas of research, and to help understand the international nature of the ISS research program from experiment recruitment through implementation. The international nature of research is based on two premises: 1) IPs chose to build certain ISS research facilities and not build others based on the understanding that IPs would share facility utilization and avoid replication, and 2) IPs would coordinate biological and physical research solicitations (internationally). The IPs were given the action to answer the following questions:

- Why is the International Space Station necessary for research?
- What research requires a short-term mission and what research necessitates a long-term mission in space?
- What are the research areas in which use of the Centrifuge on the ISS is important?

The responses from the IPs (CSA, ESA, and NASDA) were reviewed by the ReMAP Task Force and are provided in this appendix.

Meeting Minutes

Attendees:

ReMAP IP Subcommittee:
Rae Silver
Andreas Acrivos
Mary Jane Osborn
Jim Pawelczyk

NASA:
Lisa Guerra
Louis Ostrach
Bradley Carpenter
Rebecca Spyke Gardner

National Space Development Agency of Japan (NASDA)
Masato Koyama (presenter)

Canadian Space Agency (CSA):
Alan Mortimer (presenter)
John Marrone
Heinz Gindl
Graham Gibbs

European Space Agency (ESA)
Karl Knott (presenter)
Ian Pryke

IP Presentations

- CSA outlined the following as their national space priorities (in no particular order):
    - Earth and the environment
    - ISS utilization
    - Mars exploration
    - Small satellites
- ESA gave an informal presentation and will follow up with a formal written report to the ReMAP Task Force in May.
    - ESA's main goal in space research is to benefit humans on Earth.
    - There is no prioritization of research disciplines at present.
- NASDA said that the following research fields will be emphasized in the merger of Japan's three space agencies (NASDA, National Aerospace Laboratory, and Institute for Space and Aeronautical Science):
    - Microgravity Science
    - Space Biology
    - Space Medicine

International Coordination and Concerns

- CSA, ESA, and Japan have chosen to build certain ISS research facilities and not build others based on the understanding that IPs would share facility use to avoid facility replication. Changes in NASA commitments to facility provision would therefore affect all IPs.
- CSA, ESA, NASDA, and NASA internationally coordinate biological and physical research solicitations.
    - Research proposals undergo an international peer review process. The international peer review process ensures world-class science selection.
    - One agency's research proposal may use another agency's facility through the international cooperation process.
    - Cancellation of one partner's facilities therefore affects research sponsored by other partners.
    - Reduced ISS resources (e.g., crew time, upmass, etc.) will significantly reduce international research capabilities and may jeopardize continued IP participation.

The main IP concern is lack of crew time for research given a three-person crew for an extended period.

CSA Report

CANADIAN SPACE AGENCY

Further to discussions with the NASA Research Maximization and Prioritization Task Force, the Canadian Space Agency (CSA) wishes to provide input on three issues identified in our presentation to the committee on April 19, 2002.

International Cooperation for the Scientific Utilization of International Space Station (ISS)

From the outset the CSA has developed programs based on a collaborative international approach. The CSA has seen international collaboration as the most efficient and effective way to reach national goals within the budget that has been allotted. International cooperation does, however, mean that the CSA has chosen not to build certain experimental hardware that would support very high priority science objectives. At the same time, the CSA has agreed to provide to the international community hardware that is of less strategic importance nationally, components required by the overall international scientific community as part of a complete science laboratory. This is especially important for life sciences. For example, the CSA decided not to develop rodent facilities for ISS, seen as one of the highest priorities nationally, and has agreed to provide the Insect Habitat, which is of great scientific value, but which has much lower national priority.

Other Agencies have made similar decisions. Both the European Space Agency (ESA) and NASA have agreed not to build duplicate hardware for the study of human physiology and to integrate the hardware into a single laboratory co-located within the ISS. Further, early discussions amongst all ISS partners reached an agreement to build only one combustion facility so that resources could be used to build other microgravity facilities.

International cooperation in the scientific utilization of ISS has led to a shared international equipment set that allows all partners to meet their scientific objectives, making best use of the resources on ISS in an efficient and continuous manner. However, no partner will be able to meet even their high priority scientific objectives unless all agencies provide the research elements that have been mutually agreed.

International cooperation extends beyond a coordinated research facility. Currently experiments to be performed on ISS are solicited jointly by all partners using the same announcement and background information. Proposals submitted by scientists from all partner countries are reviewed by the same international peer review panel. Selection for flight is the responsibility of an international steering committee. Once selected, experiments are prepared for flight with the oversight of international implementation committees that follow progress and can make adjustments to maximize the science return to all partner agencies.

International integration of the scientific utilization of ISS has been implemented at all stages. Not only does it provide an excellent example of international cooperation, the sharing of resources and responsibility has provided the most effective approach to the maximizing of scientific return for all ISS partners.

The coordinated scientific approach benefits from the resultant, multi-national scientific teams, allowing more rapid advance in the depth and range of our knowledge.

Utilization of ISS

The CSA views the ISS as the only platform for a variety of scientific investigations. In particular:

ISS provides the only opportunity for long duration microgravity experiments:
This is good for protein crystal growth, semi-conductor crystal growth, diffusion studies, multi-generation studies of animals, radiation biology in space, physiological adaptation of humans and animals and the study of cumulative effects in both biological and physical disciplines.

ISS is human-tended:
Astronauts are required for studies in human physiology, (bone loss, cardiovascular system, radiation studies) and psychology. Astronauts allow real-time iteration of experiments in response to unexpected results, human observation of experiments and interaction with investigators. Some processes require human intervention, such as animal care over extended periods or particularly delicate manipulations.

ISS provides frequent access and experiment repetition:
ISS allows repetition and iteration of experiments within a reasonable time. This will increase the scientific rigor of the research (by increasing the experimental sample size) and allow advances to be made in the timeframe required so that the results can impact terrestrial research priorities.

Large payloads can be accommodated by ISS:
Sophisticated payloads such as Fluid Science Laboratory or the Centrifuge cannot be accommodated on most free flyers.

Transport to/from ISS is generally gentle compared to other vehicles:
When compared with free flyer options, launch and landing are relatively gentle. This is important in order to preserve protein and other crystals grown in space and to have less impact on live specimens.

Scientific Priorities

From the outset, the CSA science programs have worked on the premise that “We cannot be all things to all people”. The program has taken a focused approach to scientific research in space. Research directions have been selected with the advice of standing advisory committees and input from the wider scientific community through workshops.

Priorities have been based upon:

Areas of national priority

Areas of national excellence
Niches where Canada can significantly advance the international scientific effort
Areas with benefits on Earth

This process has led to identification of the following research areas:

Life Sciences:

<u>Bone and Muscle Loss</u>
- Significant in space, particularly for long term flight
- Relevant on earth particularly in processes of aging

<u>Cardiovascular and Metabolic Physiology</u>
- Important and for long duration flights and return to Earth
- Significant in study of heart disease and metabolic disorders

<u>Radiation</u>
- Area of national excellence
- Critical for long duration space missions
- Directly impacts radiation safety and cancer treatment on Earth

<u>Neuroscience</u>
- Long history in space research in Canada
- Wide range of applications to conditions associated with aging on Earth
- Significant applications to operational considerations during spaceflight

<u>Isolation and Multi-cultural Psychology</u>
- An area of significant national expertise and national pride
- Critical for long duration spaceflight
- Assists in many applications on Earth

Microgravity Sciences:

<u>Materials Science</u>
- Mechanisms, basic physical properties and fundamental issues
- The goal is to improve processes and products on Earth

<u>Fluid Science</u>
- Study of the motion or structure of fluids
- Use spaceflight of physical properties and processes affected by gravity

<u>Biotechnology</u>
- Study of the structure and behavior of non-living organic material
- Protein crystallization for development of structures on Earth with biomedical application

The centrifuge is a critical scientific element for the ISS

ISS partners have developed a plan for providing a set of experimental hardware, which will allow the best science from around the world to be performed on the ISS. The centrifuge is central to our ability to obtain scientific results that will be accepted by the international scientific community. The centrifuge provides the control; the comparison, to determine the changes caused by the weightless environment. A control is clearly essential in the design of animal experiments. In fact most ISS hardware has been built to make use the centrifuge for control samples. The centrifuge is however also critical for cell biology and plant biology and will also strengthen the scientific value of studies in fluid physics.

The centrifuge is also the only method currently available to create fractional gravity fields. Fractional gravity allows scientists to develop models to explain the processes that lead to changes observed during spaceflight. It remains the only approach to develop the predictive theories to explain how gravity may have an impact living and physical system.

Without the centrifuge, much of the science that is completed on ISS will be of diminished value

ESA Report

EUROPEAN SPACE AGENCY

ESA offers the following responses to three questions posed by NASA's ReMAP Task Force with regard to research on the ISS in terms of both its national and scientific importance. The questions being addressed by ESA are:

1. Justification for doing research on ISS: why is the ISS necessary for your agency's research?
2. What research requires a short-term mission and what research necessitates a long-term mission in space?
3. What are the research areas in which use of the Centrifuge on ISS is important for your agency?

Concerning the first of these questions Eighteen years ago Europe was invited amongst other Partners to participate in the joint development and exploitation of the Space Station for the pursuit of both fundamental and applied research. Since that time ESA has committed not only a significant financial engagement to develop key infrastructure elements of ISS but also in a close dialogue with NASA and other Partners for its coordinated utilization. In view of these investments ISS is the centerpiece for Europe for research in life and physical sciences in microgravity.

In answer to the second question I would like to emphasize that we do not see short and long-term missions as being separately linked to specific research areas. Clearly the effects of long-term exposure of humans to low-gravity and radiation conditions can only be researched using space stations. In the other areas such as fluid physics, biotechnology, crystal growth, cell biology, combustion etc. it is true that individual experiment runs can be relatively short (hours, days) but the days of one-off experiments research are long gone. Nowadays ESA receives proposals that are for programmes of research involving extensive iteration of parameter variations extending over weeks and months. Sounding Rocket activities are essentially for pre-cursor experiments and cannot off-load short duration experiments from ISS. Russian Foton missions offer some research possibilities but are extremely limited on real time data interaction and offer only limited interactive capability. In this connection SPACEHAB flights can offer interesting near term possibilities and ESA has been extensively involved in recent SPACEHAB missions. ESA would therefore like to suggest to the Committee that NASA be urged to consider continuing SPACEHAB research missions during the ISS assembly period.

For the last question, ESA presently develops facilities such as EMCS and BIOLAB that have their own built-in centrifuges. These facilities are directed at research in biology and small plant physiology and require only centrifuges of moderate size. ESA presently studies a mice facility that will also have a 90 cm. Centrifuge adequate for research on mice. So, up to now the research plans of ESA do not significantly require the use of the large centrifuge on ISS.

NASDA Report

NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN

NASDA offers the following responses to NASA's ReMAP Task Force in the areas of Life Sciences and Microgravity Sciences with regard to research and both its national and scientific importance.

(1) Life Science Area

a) Justification for doing research on ISS: why is the ISS necessary for your agency's research?

Whether the life is limited to the earth or universal is one of our fundamental questions. To learn about the life on earth, studying in extraterrestrial environment is particularly valuable and crucial. Previously unknown biological phenomena that were veiled with terrestrial environmental factors will come into view. The International Space Station (ISS) will provide a unique environment other than the earth surface for observing biological phenomena. Findings on the ISS will not only be essential for the human space activity, but also give us great insight to the principle of the life.

b) What research requires a short-term mission and what research necessitates a long-term mission in space?

Biological phenomena consist of many processes with various time scales. Some, such as nerve excitement, complete within a second while others, human senescence for example, take years. Space motion sickness shows remission in a few days, while bone loss keeps progress. Thus, the period required for biological experiments varies. The ISS meets experimental requirements

c) What are the research areas in which use of the Centrifuge on ISS is important for your agency?

Since numerous factors affect biological responses, quantitative observations must be made in comparison with control groups. Experimental group and control groups are required to differ only in a single parameter. Other parameters must be kept exactly identical. Artificial gravity generator or the Centrifuge is thus indispensable for the entire gravitational biology research. The Centrifuge is also essential to keep experimental organisms under earth-like conditions and ready to be exposed to the space environment without remaining influence of the launch.

(2) Micro Gravity Science Area

a) Justification for doing research on ISS: why is the ISS necessary for your agency's research?

Microgravity is an environmental factor, just as ultra-high vacuums, super-high temperature, super-high pressure and high-energy radiation are. These environmental factors may work positively to aid understanding of unclear phenomena, verification of theories and/or fabrication of new functional materials. They can also be expected to contribute to the acquisition of innovative knowledge when used as tools for analyzing various phenomena.

The use of microgravity itself seldom facilitates the establishment of innovative theorems. Instead, by taking advantage of the symmetry attained from the gravity-free state, we should use it for verifying conventional theories; for verifying theorems using simplified models that eliminate the complexity of ground convection-related phenomenon; for simplifying phenomena by excluding the transport factor (namely, convection); for obtaining high-precision measurements of thermophysical properties, and for improving the function and quality of materials characteristics. ISS is the best opportunity for these microgravity science research activities.

For the fundamental physics, in order to observe or realize the steady state of the quantum physics phenomena, the microgravity condition is significantly beneficial because the quantum itself become free from the gravity acceleration.

b) What research requires a short-term mission and what research necessitates a long-term mission in space?

Method (duration)	Research Area
Drop tower (<10s)	Combustion, Fluid physics (ex. bubble movement, etc), experimental technology developments, Plasma physics
Aircraft (<20s)	Combustion, experimental technology developments, Fluid physics (ex. bubble movement, two phase flow, etc),
Sounding rocket (<6min)	Combustion, solidification (alloys, composites, etc), High precise thermo-physical measurements, Fluid physics (ex. boiling, etc), Colloid physics
Space shuttle (< 2weeks)	Diffusion (self diffusion, inter diffusion), solidification (alloys, etc), High precise thermo-physical measurements, Fluid physics (ex. Marangoni convection, etc), Composites, Crystal growth mechanism, Crystal growth from melt (semi-conductor), protein crystal growth
ISS	Crystal growth from melts and solution (semi-conductor, protein, etc.), solidification (alloys, composites, etc.), High precise thermo-physical measurements, Diffusion (self diffusion, inter diffusion), Fluid physics (ex. Marangoni convection, etc), Fundamental Physics (laser cooling, atomic clock, etc)